CALIBRATION PROCEDURE

NI 5900

This document contains instructions for writing an external calibration procedure for the National Instruments PXI-5900 differential amplifier (NI 5900). This calibration procedure is intended for metrology labs. For more information about calibration, visit `ni.com/calibration`.

Contents

Conventions

The following conventions are used in this document:

This icon denotes a note, which alerts you to important information.

bold — Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic — Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

`monospace` — Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

Software Requirements

Calibrating the NI 5900 requires installing NI-SCOPE version 3.5.1 or later on the calibration system.You can download NI-SCOPE from the Instrument Driver Network at `ni.com/idnet`. NI-SCOPE supports programming the *Verification* section in a number of programming languages. However, only LabVIEW and C are supported for the *Adjustment* section.

NI-SCOPE includes all the functions and attributes necessary for calibrating the NI 5900. LabVIEW support is installed in `niScopeCal.llb`, and all calibration functions appear in the function palette. For LabWindows™/CVI™, the NI-SCOPE function panel `niScopeCal.fp` provides further help on the functions available in CVI. Refer to the *NI-SCOPE Readme* for installed file locations.

Calibration functions are LabVIEW VIs or C function calls in the NI-SCOPE driver. The C function calls are valid for any compiler capable of calling a 32-bit DLL. Many of the functions use constants defined in the `niScopeCal.h` file. To use these constants in C, you must include `niScopeCal.h` in your code when you write the calibration procedure.

Documentation Requirements

You may find the following documentation helpful as you write your calibration procedure:

- *NI High-Speed Digitizers Getting Started Guide*
- *NI High-Speed Digitizers Help*
- *NI 5900 Specifications*
- *NI-SCOPE Readme*

These documents are installed with NI-SCOPE. You can also download the latest versions from the NI Web site at `ni.com/manuals`.

Calibration Interval

The measurement accuracy requirements of your application determine how often you should verify and adjust your device. NI recommends that you perform a complete verification for the NI 5900 at least once every two years. If the instrument fails any of the performance tests, adjustment or repair is required.

Test Equipment

Table 1 lists the equipment required for externally calibrating the NI 5900. If you do not have the recommended instruments, use these specifications to select a substitute calibration standard.

Table 1. Required Equipment Specifications for NI 5900 External Calibration

Required Equipment	Recommended Equipment	Where Used	Specification
Digital Multimeter (DMM)	NI PXI-4070	Vertical offset, vertical gain	DC V accuracy: ±0.01% DC V input impedance: 10 GΩ
Signal Generator	Fluke 9500B oscilloscope calibrator or Wavetek 9500 with high-stability reference option Fluke 9530 test head	Vertical offset and vertical gain Bandwidth and flatness	DC Accuracy: ±(0.05% ±100 μV) into 1 MΩ Flatness: ±2% output amplitude flatness for leveled sine wave up to 10 MHz relative to 50 kHz into 1 MΩ or 50 Ω
Power Meter/Sensor	Rohde & Schwarz NRP-Z91	Bandwidth and flatness	Relative power accuracy ≤ 0.022 dB
50 Ω BNC Terminator	Pasternack Enterprises PE6156	Bandwidth and flatness	—

Test Conditions

Follow these guidelines to optimize the connections and the environment during calibration:

- Keep cables as short as possible. Long cables act as antennae, picking up noise that can affect measurements. To further reduce settling and noise, use shielded twisted-pair PTFE-insulated cables.
- Verify that all connections, including front panel connections, are secure.
- Ensure that the PXI chassis fan speed is set to HI, that the fan filters are clean, and that the empty slots contain filler panels. For more information, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `ni.com/manuals`.
- Keep relative humidity between 10% and 90%, non-condensing.
- Maintain an ambient temperature of 23 °C ±5 °C.
- Allow a warm-up time of at least 15 minutes after the NI-SCOPE driver is loaded. Unless manually disabled, the NI-SCOPE driver automatically loads with the operating system and enables the device.

Calibration Procedures

The calibration process includes the following steps:

1. *Initial Setup*—Install the device and configure it in Measurement & Automation Explorer (MAX).
2. *Verification*—Procedure to confirm whether the device is operating within its published specifications.
3. *Adjustment*—Perform an external adjustment of the device that calculates new calibration constants to optimize the instrument performance. The adjustment procedure automatically stores the calibration date on the EEPROM.
4. Reverification—Repeat the verification procedure to ensure that the device is operating within its specifications after adjustment.

These steps are described in detail in the following sections.

Initial Setup

Refer to the *NI High-Speed Digitizers Getting Started Guide* for information about how to install the software and hardware, and how to configure the device in MAX.

Verification

This section describes the process used to verify the NI 5900 performance compliance with the published specifications. Verification tests the following NI 5900 specifications:

- Vertical offset and vertical gain
- Bandwidth and flatness
- 50 Ω input impedance

Note If the NI 5900 passes all of the verification tests within the specified limits, performing the *Adjustment* procedure is optional.

Verifying Vertical Offset and Vertical Gain

Table 2 contains the equipment configuration settings for verifying vertical offset and vertical gain.

To verify vertical offset and vertical gain, complete the following procedure for each step in Table 3.

Table 2. Equipment Configuration for Vertical Offset and Vertical Gain Verification

NI 5900		Signal Generator	DMM			
Input Impedance	Input Coupling	Expected Load Impedance	Function	Range*	Input Impedance†	Resolution
1 MΩ	DC	1 MΩ	DC Voltage	3 V	10 GΩ	6 1/2 Digits

* Use the smallest DMM range that is greater than the value listed in this table.

† The input impedance should be equal or greater than the values indicated in the table.

Table 3. Equipment Configuration and Test Limits for Vertical Offset and Vertical Gain Verification

Step	BNC Terminator Connection	Signal Generator		NI 5900 Output Terminal	Test Value (V)	Test Limit (V)
		Connection	Voltage (V)			
1	CH 0–	CH 0+	+10.0	Out 0	+10	±(0.2% of Input + 500 µV)
2	CH 0–	CH 0+	0	Out 0	0	±(0.2% of Input + 500 µV)
3	CH 0+	CH 0–	+10.0	Out 0	–10	±(0.2% of Input + 500 µV)
4	CH 1–	CH 1+	+10.0	Out 1	+10	±(0.2% of Input + 500 µV)
5	CH 1–	CH 1+	0	Out 1	0	±(0.2% of Input + 500 µV)
6	CH 1+	CH 1–	+10.0	Out 1	–10	±(0.2% of Input + 500 µV)

1. Read the CalGain constant from the NI 5900 calibration EEPROM by accessing the NI-SCOPE Accessory Gain property or the `NISCOPE_ATTR_SIGNAL_COND_GAIN` attribute.
2. Read the CalOffset constant from the NI 5900 calibration EEPROM by accessing the NI-SCOPE Accessory Offset property or the `NISCOPE_ATTR_SIGNAL_COND_OFFSET` attribute.
3. Configure the DMM, signal generator, and NI 5900 for the settings shown in Table 2.
4. Set the signal generator output voltage to 0.
5. Connect the DMM to the NI 5900 output terminal as shown in Table 3 for the appropriate step. Refer to Figure 1 for connection information.

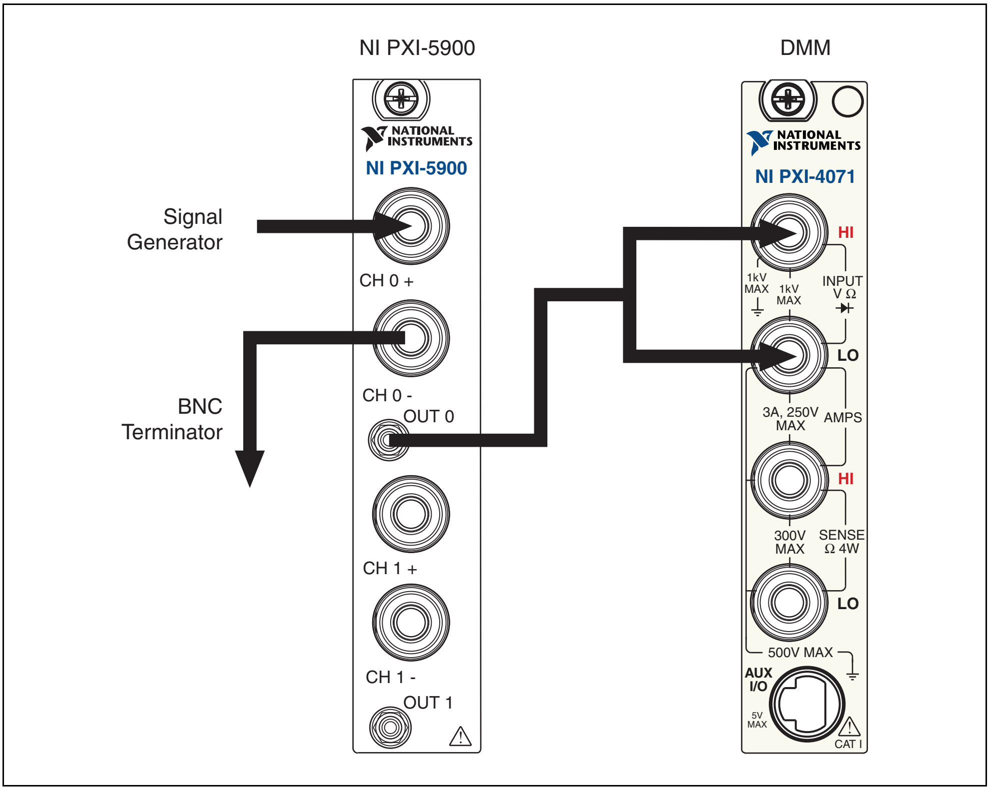

Figure 1. Vertical Offset and Vertical Gain Verification Connections

6. Connect the BNC Terminator as shown in Table 3 for the appropriate step.
7. Connect the signal generator as shown in Table 3 for the appropriate step.
8. Configure the signal generator output voltage as shown in Table 3 for the appropriate step.

9. Wait 2 seconds for the system to settle.
10. Read the output voltage, *DMMOutputVoltage*, with the DMM.
11. Calculate *MeasuredValue* using the equation:

$$MeasuredValue = \frac{DMMOutputVoltage - CalOffset}{CalGain}$$

where

DMMOutputVoltage is obtained from step 10

CalOffset is obtained from step 2

CalGain is obtained from step 1

12. Record *MeasuredValue*. Compare *MeasuredValue* to the test value in Table 3 and calculate the output error.
13. Compare the output error to the *Test Limit* for the appropriate step in Table 3.
14. Set the signal generator output voltage to 0.
15. Repeat steps 5 through 14 for each step in Table 3.

Verifying Bandwidth and Flatness

To verify bandwidth and flatness, complete the following procedure for each step in Table 4.

Table 4. Equipment Configuration for Bandwidth and Flatness Verification

Step	Signal Generator Connection	BNC Terminator Connection	Power Meter Connection
1 (part A)	CH 0+	CH 0–	Out 0
1 (part B)	CH 0–	CH 0+	Out 0
2 (part A)	CH 1+	CH 1–	Out 1
2 (part B)	CH 1–	CH 1+	Out 1

Table 5. Reference Power (P_{REFCH0}+) Test Limit

Reference Power Nominal Value	Test Limit
39.1 µW	±4 µW

Table 6. Frequency Test Points and Test Limits for Bandwidth and Flatness Verification

Frequency	Test Limit
1 MHz	±1 dB
2 MHz	±1 dB
3 MHz	±1 dB
4 MHz	±1 dB
5 MHz	±1 dB
6 MHz	±3 dB

1. Configure the power meter as follows:
   - Average: Auto
   - Measure: watts
   - Resolution: .01 dB
2. Set the signal generator output voltage to 0.
3. Configure the NI 5900 input coupling to DC.
4. Configure the NI 5900 input impedance to 50 Ω.
5. Configure the output impedance of the signal generator to match the input impedance of the NI 5900.
6. Connect the BNC terminator to the NI 5900 terminal as shown in Table 4 for part A of the appropriate step.
7. Connect the signal generator to the NI 5900 terminal as shown in Table 4 for part A of the appropriate step.
8. Connect the power meter to the NI 5900 terminal as shown in Table 4 for part A of the appropriate step.
9. Configure the signal generator output voltage amplitude to 1 Vpp.
10. Configure the signal generator output frequency to 50 kHz.
11. Wait 2 seconds for the system to settle.
12. Measure and record the reference power ($P_{REFCH0+}$). Compare the reference power ($P_{REFCH0+}$) to the test limit in Table 5.
13. Complete steps 13 a to 13 c for each frequency in Table 6.
    a. Configure the signal generator output frequency as shown in Table 6.
    b. Wait 2 seconds for the system to settle.
    c. Measure and record the power at the set frequency (P_{CH0+}).

14. Configure the signal generator output voltage amplitude to 0.
15. Connect the BNC terminator to the NI 5900 terminal as shown in Table 4 for part B of the appropriate step.
16. Connect the signal generator to the NI 5900 terminal as shown in Table 4 for part B of the appropriate step.
17. Connect the power meter to the NI 5900 terminal as shown in Table 4 for part B of the appropriate step.
18. Configure the signal generator output voltage amplitude to 1 Vpp.
19. Configure the signal generator output frequency to 50 kHz.
20. Wait 2 seconds for the system to settle.
21. Measure and record the reference power ($P_{REFCH0-}$).
22. Complete steps 22 a through 22 c for each frequency in Table 6.
    a. Configure the signal generator output frequency as shown in Table 6.
    b. Wait 2 seconds for the system to settle.
    c. Measure and record the power at the set frequency (P_{CH0-}).
23. For each frequency in Table 6, calculate the error:

$$Error = 10 \times \log\left(\frac{(P_{CHO+}) + (P_{CHO-})}{(P_{REFCHO+}) + (P_{REFCHO-})}\right)$$

    Compare the error to the *Test Limit* for the appropriate frequency in Table 6. Note that for the error formula, the power values should have units of watts.
24. Set the signal generator output voltage amplitude to 0.
25. Repeat steps 6 through 24 for each step in Table 4.

Verifying 50 Ω Input Impedance

To verify 50 Ω impedance accuracy, complete the following procedure for each step in Table 7.

Table 7. Equipment Configuration and Test Limits for 50 Ω Input Impedance Verification

Step	DMM Connection	DMM Nominal Reading	Test Limit (V)
1	CH 0+	50 Ω	±2%
2	CH 0–	50 Ω	±2%

Table 7. Equipment Configuration and Test Limits for 50 Ω Input Impedance Verification (Continued)

Step	DMM Connection	DMM Nominal Reading	Test Limit (V)
3	CH 1+	50 Ω	±2%
4	CH 1–	50 Ω	±2%

1. Configure DMM for resistance measurement.
2. Configure NI 5900 input impedance to 50 Ω.
3. Configure NI 5900 input coupling to DC.
4. Connect DMM to the NI 5900 terminal as shown in Table 7 for the appropriate step.
5. Measure and record the resistance.
6. Calculate the error to the nominal reading and compare the error to the *Test Limit* for the appropriate step in Table 7.
7. Repeat steps 4 through 6 for each step in Table 7.

Adjustment

Note Allow the NI 5900 and support equipment to warm up for a minimum of 15 minutes prior to performing an adjustment.

To adjust vertical offset and vertical gain, complete the following procedure.

Table 8. Equipment Configuration for Vertical Offset and Vertical Gain Adjustment

NI 5900		DMM			
Input Impedance	Input Coupling	Function	Range*	Input Impedance†	Resolution
1 MΩ	DC	DC voltage	3 V	10 GΩ	6 1/2 digits

* Use the smallest DMM range that is greater than the value listed in this table.

† The input impedance should be equal or greater than the values indicated in the table.

1. Open an external calibration session by calling the niScope Cal Start VI or the `niScope_CalStart` function. The default password for this VI or function is `"NI"`.
2. Configure the DMM and the NI 5900 for the settings shown in Table 8.
3. Connect the DMM to the OUT 0 terminal of the NI 5900.

4. Set the NI 5900 calibration source of CH 0 to PostiveFS (+10 V) using the niScope Cal Set Accessory Source VI or the `niScope_Cal SetAccessorySource` function.
5. Wait 2 seconds for the system to settle.
6. Read the output voltage, *DMMPostiveFS*, with the DMM.
7. Set the NI 5900 calibration source of CH 0 to GND using the niScope Cal Set Accessory Source VI or the `niScope_CalSetAccessory Source` function.
8. Wait 2 seconds for the system to settle.
9. Read the output voltage, *DMMGround*, with the DMM.
10. Set the NI 5900 calibration source of CH 0 to NegativeFS (–10 V) using the niScope Cal Set Accessory Source VI or the `niScope_CalSetAccessorySource` function.
11. Wait 2 seconds for the system to settle.
12. Read the output voltage, *DMMNegativeFS*, with the DMM.
13. Using the *DMMPositiveFS*, *DMMGround*, and *DMMNegativeFS* parameters, call the niScope Cal Adjust Accessory Gain and Offset VI or the `niScope_CalAdjustAccessoryGainAndOffset` function for CH 0.
14. Repeat steps 3 through 13 for CH 1 (OUT 1).
15. Close the external calibration session by calling the niScope Cal End VI or `niScope_CalEnd` function. When calling this VI or function, set the **action** parameter to store the calibration results in the EEPROM.

You have completed the adjustment portion of the calibration procedure. You should repeat the entire *Verification* procedure to verify a successful adjustment.

Note If any of the verification tests fail immediately after you perform an external adjustment, make sure that you have met the requirements listed in the *Test Equipment* and *Test Conditions* sections before you return the digitizer to National Instruments for repair.

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